Impact of Acute, Major Infrastructure Failure on Emergency Medical Service Transport Times in Rhode Island

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ABSTRACT

OBJECTIVES: Pre-hospital emergency care depends on reliable infrastructure. On December 11, 2023, the westbound span of the Washington Bridge connecting eastern and western Rhode Island (RI) closed emergently due to structural issues. This study examines the impact of sudden infrastructure failure on Emergency Medical Services (EMS) transport in RI.

METHODS: This retrospective observational study used a Rhode Island Department of Health dataset of 911 EMS calls from December 11, 2023 to December 11, 2024. Response-to-scene time, scene-to-destination time, and hospital destination for six months preceding bridge closure, the four days of full closure, and six months after the closure were compared, with additional comparison for the municipalities most likely to use this bridge (the "East Bay").

RESULTS: 911-call volume and distribution did not significantly change. Statewide mean response-to-scene times increased from 4.64 min (SD 3.16) pre-closure to 4.88 min (SD 3.14) (p<.001) following full closure, while scene-to-destination times decreased from 10.57 min (SD 6.84) to 10.04 min (SD 6.64) (p<.001). No significant statewide differences were observed during the full-closure period. The East Bay, however, saw significantly increased scene-to-destination times during full closure and post-closure (17.00 min, SE=6.59; and 15.97 min, SE=7.04, compared to 14.97 min, SE=6.75 pre-closure, p<.001). Response-to-scene times in the East Bay did not significantly change. East Bay EMS decreased the use of general adult hospitals requiring travel over this bridge without significant difference in transport to specialty hospitals.

CONCLUSIONS: This study demonstrates that major infrastructure failures significantly affect ambulance transport times and destination patterns, highlighting the need to understand infrastructure vulnerability in emergency planning.

KEYWORDS: disasters; Emergency Medical Services; infrastructure failure; response time; transport time

INTRODUCTION

America's infrastructure is aging. According to the 2021 American Society of Civil Engineers Report Card, the United States (US) faces a 10-year deficit in infrastructure investment of over $2.5 trillion.[1] The American Road & Transportation Builders Association reports that 1 in 3 US bridges are in need of repair or replacement.[2] The effects of aging and under-investment on US infrastructure are only compounded by global climate change.[3] As ambulances are dependent on roadways and local infrastructure to safely transport patients to Emergency Departments (EDs) for definitive care, infrastructure failure can pose significant challenges to EMS systems across the US. Disaster events that render infrastructure unusable, such as flooding, can have a complex and far-reaching impact on the delivery of EMS care, with consequences extending well beyond the areas directly serviced by affected roadways.[4] Prior studies of hyperacute infrastructure failures, such as the I-35W bridge collapse in Missouri in 2007, have demonstrated issues with EMS patient tracking and communication, but have not examined longer-term impacts on transport times and destination patterns.[5]

EMS response and transport times can have a significant impact on patient morbidity and mortality.[6-8] Time from dispatch to EMS arrival on scene likely has the greatest impact on patient outcomes.[9] Prior analysis shows that EMS response times are highly influenced by transportation infrastructure and local traffic variability.[10] EMS also face significant challenges with traffic congestion, particularly on interstates and national highways.[11] These effects may be especially pronounced in socioeconomically vulnerable areas.[12]

In Rhode Island (RI), on December 11, 2023, an inspection revealed that the westbound span of the Washington Bridge servicing Interstate-195 was critically structurally unsound. This resulted in an emergent, sudden closure of the main thoroughfare connecting eastern RI and the Massachusetts coast to Providence and the rest of the State. This created lasting traffic disruptions across the Providence metropolitan area, effectively severing the state's eastern portion. For the four days of full closure, all civilian traffic over the Washington Bridge completely halted, though ambulances were allowed to cross the bridge heading westbound one at a time. This process required the driver to contact their dispatch as an intermediary to gain approval to cross the bridge, but could begin over the radio immediately upon leaving the scene to expedite the bridge crossing. Of note, the State's only adult trauma/comprehensive stroke center and children's hospital are on the western side of the Washington Bridge.

This study aimed to assess the impact of this sudden infrastructure failure on EMS operations. Specifically, the objective of the study was to compare the impact of this infrastructure failure on EMS operations before and after the bridge closure on time-to-scene, time-to-destination, and hospital destinations in Rhode Island. In addition, this study examined how this emergent bridge closure impacted EMS operations in the East Bay towns most impacted by this closure.

METHODS

Study Design and Parameters

This is a retrospective observational study using a Rhode Island Department of Health dataset via BioSpatial (© ImageTrend, Durham, NC), recording all 911 EMS calls from 6/11/23–6/11/24 run by RI-based EMS. Response-to-scene times, scene-to-destination times, and choice of hospital destination were analyzed. This project was IRB-approved by the Rhode Island Department of Health (IRB #2025-02).

Data Analysis

Data were analyzed using independent t-tests with winsorization to address outliers. We categorized calls by date: pre-closure ((June 11, 2023 to December 10, 2023), acute-phase closure (December 11, 2023 to December 14, 2023), and post-closure ((December 15, 2023 to June 11, 2024). A subgroup analysis and additional analysis of hospital destination choice was then conducted for the East Bay towns most directly dependent on the Washington Bridge: East Providence, Riverside, Barrington, Bristol, and Warren.

The data were analyzed using R (version 4.4.1) within RStudio. Ambulance transports were classified into three periods based on the date of service: pre-closure (June 11, 2023 to December 10, 2023), full-closure (December 11, 2023 to December 14, 2023), and post-closure (December 15, 2023 to June 11, 2024). For transport-time variables, response-to-scene and scene-to-destination times values were set to a minimum of one minute to address implausibly low entries. To minimize the influence of outliers, values above the 99th percentile for each time variable were winsorized by replacing them with the 99th percentile value.

Descriptive statistics for EMS transport times were calculated and are reported as means with standard deviations (SD), as well as medians and interquartile ranges (IQR), for each closure period and relevant subgroups. To evaluate differences in EMS transport times across the three closure periods, we first conducted an analysis of variance. When a significant overall difference was observed, a pairwise two-sample t-test with Bonferroni correction was conducted to identify which specific closure periods differed.

Given that the Washington Bridge primarily serves East Bay communities, connecting them to downtown Providence (where local specialty hospitals are located), a subgroup analysis was conducted on EMS transports originating from East Providence, Riverside, Barrington, Bristol, and Warren. Within this subgroup, summary statistics for transport times were calculated, and independent two-sample t-tests were used to compare pre-closure and post-closure periods. Hospital destinations were summarized as frequencies and percentages for each period. Changes in hospital-utilization patterns were assessed using chi-square tests, with Fisher's exact test applied when expected counts were small.

Secondary analyses focused on EMS transports to specialty centers, specifically a Level 1 trauma center/comprehensive stroke center and a children's hospital. Summary statistics for transport times and destination proportions were calculated, and independent two-sample t-tests were used to compare pre-closure and post-closure periods.

RESULTS

Over the year-long study period, 125,817 EMS transports were analyzed across three periods: 72,296 (57.46%) pre-closure, 1,382 (1.10%) during the full closure, and 52,139 (41.44%) post-closure. During the full closure, statewide response-to-scene and scene-to-destination times were not significantly different from pre-closure: response-to-scene time of 4.71 minutes (SD 2.99) vs 4.64 minutes (SD 3.16) and scene-to-destination of 10.77 minutes (SD 6.78) vs 10.57 minutes (SD 6.84). Comparing the pre-closure period to the post-closure period, statewide mean response-to-scene times significantly increased from 4.64 minutes (SD 3.16) to 4.88 minutes (SD 3.14) ($p<.001$), while scene-to-destination times significant decreased from 10.57 minutes (SD 6.84) to 10.04 minutes (SD 6.64) ($p<.001$) [**Table 1**].

For the East Bay subset, 10,346 transports were analyzed: 6,475 (62.58%) pre-closure, 159 (1.54%) during full closure, and 3,712 (35.88%) post-closure. The East Bay saw significantly increased scene-to-destination times during the full closure and post-closure compared to pre-closure (17.00 minutes, SD 6.59 and 15.97 minutes, SD 7.04; compared to 14.97 minutes, SD 6.75 $p<.001$) [**Figure 1**]. Response-to-scene times in the East Bay did not significantly change [**Table 2**].

East Bay EMS decreased the use of general adult hospitals requiring travel over the affected bridge. However, transport to specialized hospitals remained the same; there was no significant difference in transport to the area's only adult Level 1/comprehensive stroke center, or to the area children's hospital ($p = .63$ and $.19$) [**Table 3**].

Table 1. EMS Transports Across RI Before, During, and After the Washington Bridge Closure, in Minutes

Outcome	Pre-Closure (N = 72,296)		Full Closure (N = 1,382)		Post-Closure (N = 52,139)	
Response-to-Scene	Mean: 4.64	SD: 3.16	Mean: 4.71	SD: 2.99	Mean: 4.87	SD: 3.14
	Median: 4.0	IQR: 2.3, 6.2	Median: 4.1	IQR: 2.6, 6.1	Median: 4.2	IQR: 2.7, 6.4
	Min: 1.0	Max: 63.2	Min: 1.0	Max: 19.7	Min: 1	Max: 51.6
Scene-to-Destination	Mean: 10.57	SD: 6.83	Mean: 10.77	SD: 6.78	Mean: 10.04	SD: 6.64
	Median: 9.0	IQR: 5.6, 13.9	Median: 9.3	IQR: 5.9, 14.0	Median: 8.5	IQR: 5.3, 12.9
	Min: 1	Max: 138.6	Min: 1	Max: 38.8	Min: 1	Max: 68.0

Figure 1. Bridge Closure, Full-closure, Post-closure

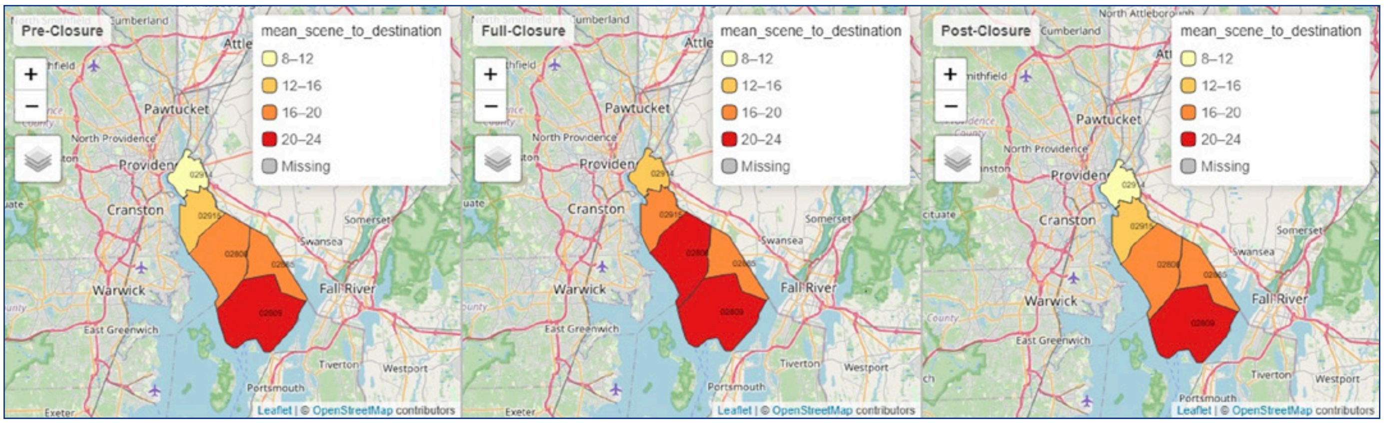

Table 2. EMS Transports in the East Bay Before, During, and After the Washington Bridge Closure, in Minutes

Outcome	Pre-Closure (N = 6,475)		Full Closure (N = 159)		Post Closure (N = 3,712)	
Response-to-Scene	Mean: 4.54	SD: 3.10	Mean: 4.88	SD: 2.80	Mean: 4.59	SD: 3.09
	Median: 4.00	IQR: 2.60, 5.60	Median: 4.50	IQR: 2.90, 6.30	Median: 3.95	IQR: 2.70, 5.60
	Min: 1	Max: 63.20	Min: 1	Max: 14.70	Min: 1	Max: 40.30
Scene-to-Destination	Mean: 14.97	SD: 6.75	Mean: 17.00	SD: 6.59	Mean: 15.97	SD: 7.04
	Median: 14.30	IQR: 9.90, 19.80	Median: 17.00	IQR: 11.40, 21.60	Median: 15.20	IQR: 10.30, 21.00
	Min: 1	Max: 36.60	Min: 1	Max: 34.90	Min: 1	Max: 41.90

Table 3. East Bay Destination Choices, N = 10,346 transports

Hospital	Pre-Closure N (%)	Full Closure N (%)	Post-Closure N (%)	p-value (Pre Vs Post)
L1TC / Comprehensive Stroke Center *	2800 (43.24%)	65 (40.88%)	1587 (42.75%)	0.77
Children's Hospital *	295 (4.56%)	5 (3.14%)	191 (5.15%)	0.28
General Adult Hospital A*	1787 (27.60%)	38 (23.90%)	901 (24.27%)	<0.001
General Adult Hospital B	745 (11.51%)	30 (18.87%)	495 (13.34%)	<0.001
General Adult Hospital C	226 (3.49%)	8 (4.98%)	185 (5.03%)	<0.001
General Adult Hospital D	288 (4.45%)	3 (1.89%)	143 (3.85%)	0.13
General Adult Hospital E	158 (2.44%)	6 (3.77%)	110 (2.96%)	0.15

* = requires use of the affected bridge

DISCUSSION

Despite the critical nature of the Washington Bridge connecting the two sides of Rhode Island, the results of this study suggest that the effect of infrastructure failures on EMS transport time may not be as far-reaching as initially expected. Given the ability of EMS to route to alternative general hospitals, the results suggest infrastructure failures are likely to be most consequential for patients requiring transport to a specialty center for specific care.

In contrast to the East Bay-specific results, the statewide changes in response-to-scene and scene-to-destination times before and after bridge closure, while statistically significant, are unlikely to be clinically significant for the vast majority of EMS patients. A 2025 study found that only 6% of EMS activations involved a time-critical prehospital intervention, and 12% involved a time-critical ED intervention.[13] The literature varies significantly on the protective effects of various response times. Several studies note a potential protective effect of response times under 4-to-5 minutes; however, this is likely economically infeasible, and other studies show questionable patient benefit in response times between 5 and 10 minutes for even critically ill patients.[13–15] The net statewide decrease in EMS transportation time before and after bridge closure was a surprising finding of this study, though potential confounders such as types of EMS calls and statewide traffic patterns were not explored. This could be due to EMS agencies deciding to transport patients to closer hospitals when appropriate (e.g., the patient was not clearly in need of specialty services). Most notably, there was no change in EMS response-to-scene or scene-to-destination times during the acute phase of the bridge closure, when all civilian traffic from the East Bay and southern Massachusetts was diverted through residential neighborhoods and any other roads available. An additional possible confounder is the new work-from-home flexibilities for many workers, allowing many Rhode Islanders to choose to work from home to avoid the delays caused by this bridge failure. This may have resulted in a significant traffic burden reduction throughout the State.

The effects of infrastructure failure, though localized, are persistent. Notably, the magnitude of increase in scene-to-destination times was larger in the six months following the full bridge closure than it was during the acute phase of the bridge closure. This is despite the Rhode Island Department of Transportation (RIDOT) successfully rerouting four lanes of traffic in each direction into two lanes of traffic in each direction using exclusively the eastbound bridge span and continuing to add lanes over the following months. This may be an effect of RIDOT's treatment during the acute phase of the bridge closure, wherein one ambulance at a time was allowed to pass over the defunct westbound bridge span.

Perhaps most importantly, the study results show that the bridge closure resulted in significantly different hospital destination patterns for general adult patients in the East Bay. Under normal circumstances, transport times are only one factor involved in deciding where EMS takes patients. One US-based study indicates that roughly one-third of all EMS transports bypassed the nearest ED in favor of another facility.[16] When possible, EMS systems are likely to respond to infrastructure failures by transporting patients to alternate hospitals. This shift in transportation patterns could impose a significant burden on the receiving facilities; EMS patients, on average, are older, have more comorbidities, have higher triage scores, use more ED resources, and have longer lengths of ED stay than ED patients arriving by other means.[17]

Transports to the regional children's hospital and area trauma/comprehensive stroke center did not change during the study period, which is both logical and consistent with previous literature. Previous research suggests that less than half of pediatric patients are transported to the closest facility, transporting instead to the patients' and/or family's choice of hospital or hospital with specialty services.[18] Similar work on trauma patients indicates that only about one-fifth of these patients were transported to the closest facility, instead being transported to the patient's preferred destination or to a hospital with specialty services.[19] The results of this study show that EMS agencies did not reroute patients requiring specialty services. While this is an encouraging finding for quality of patient care, it also means these patients were likely most impacted by increased scene-to-destination times from the infrastructure failure.

Limitations

This study examined data from only one state, which must be addressed when considering generalizability. Data were unable to be obtained from neighboring Massachusetts towns comprising parts of the Providence metropolitan area, which the Washington bridge closure would have also impacted. Consequently, the analysis may underestimate the full regional impact of the closure. As these Massachusetts town also use the bridge and must use the highway for longer stretches than East Bay communities, it could be theorized that the impact of the Washington Bridge closure on EMS transports in the Providence metropolitan area would be more pronounced had the authors been able to access this data. Additionally, these Massachusetts towns can access alternative general hospitals more easily (especially those in the city of Fall River) and have elected instead to transport to a Level II trauma center with primary stroke capabilities and limited pediatric services that is approximately 30 miles east of the Washington Bridge. Zip-code level data for GIS analysis were also used, which may obscure more granular details of the impact of bridge closure. No qualitative component to this study was conducted, and thus this study cannot fully determine the factors impacting EMS clinician choice of destination hospital. Finally, there were no publicly available data to determine the overall traffic burden during the study period, limiting direct correlation between traffic congestion and transportation times.

CONCLUSIONS

This study demonstrates that major infrastructure failures have persistent negative impacts on ambulance transport times for months, though in a relatively geographically limited pattern. Importantly, destination patterns for adult patients not requiring specialty services significantly changed as a result of this infrastructure failure, with EMS transporting fewer patients to general adult hospitals that required use of the affected bridge during transit. There was no change in destination patterns to hospitals with specialty services, such as trauma/comprehensive stroke services or the area's pediatric hospital. EDs and EMS agencies should consider these effects when assessing readiness, as these may have lasting impacts on ambulance transportation and utilization patterns as well as ED-patient burden.

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